

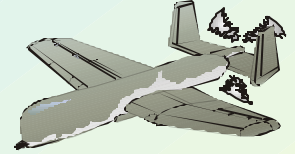


Networked Sensors for the Objective Force

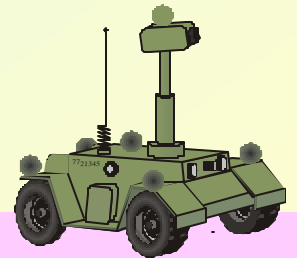
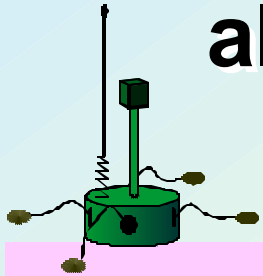
“No Place To Hide”

Mr. John Eicke
U.S. Army Research Laboratory

Objective

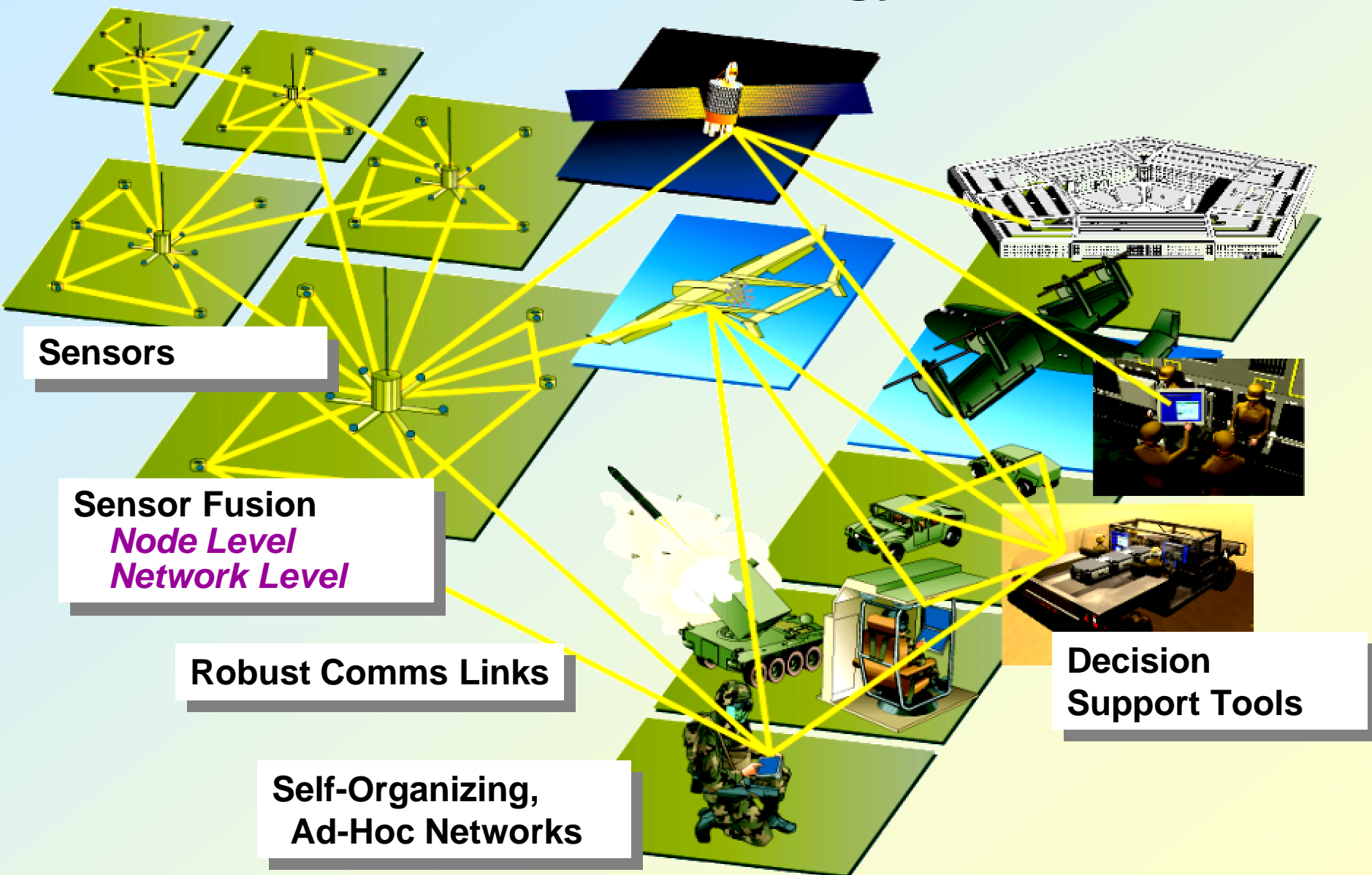


Demonstrate a family of low cost sensors utilizing a wide range of sensor types, to enable overarching situational awareness & provide a common operational picture across all echelons of the future Army.



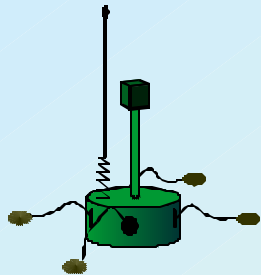
Networks of ubiquitous, low cost sensors can “see” where we currently cannot!

Networked Sensors: Technology Enablers



What's the Concept ?

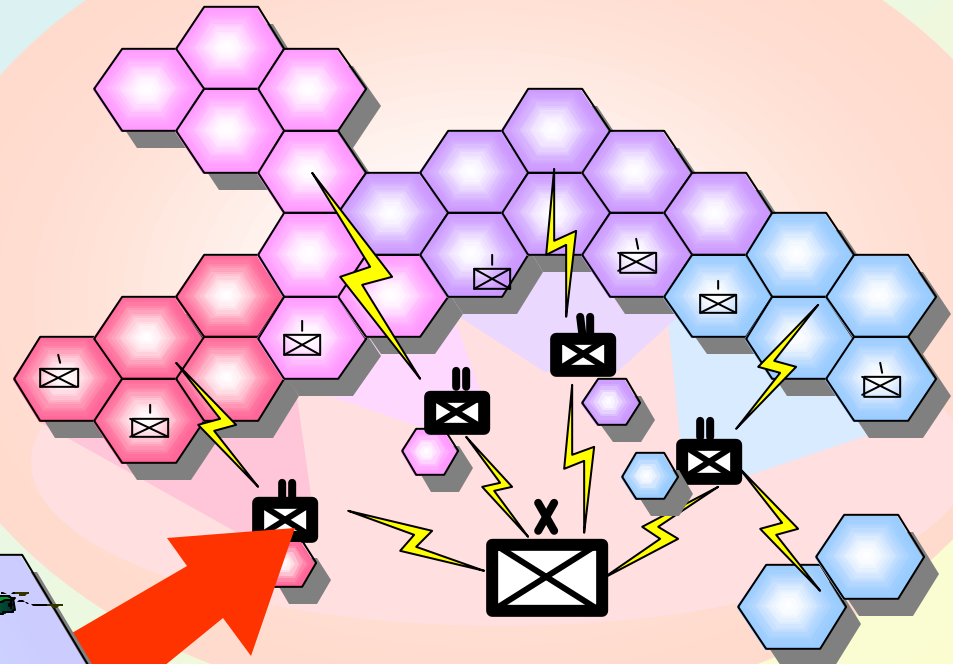
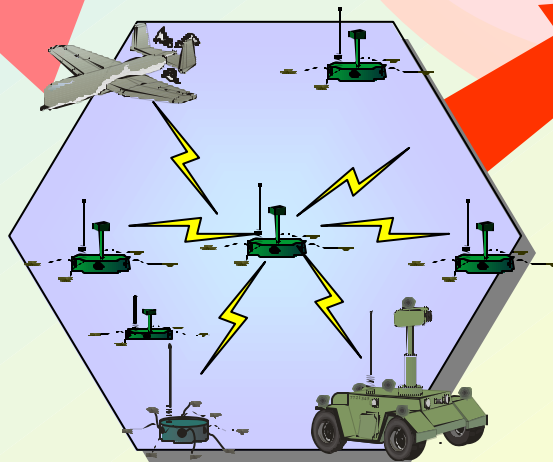
The Network is the Sensor!



UGS

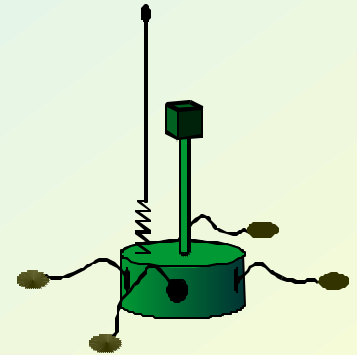
UGV's

UAV's

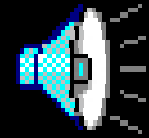
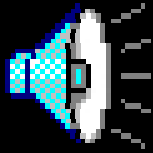


What Does All This Mean to the Warfighter ?

- High fidelity sensor information for
 - *Targeting*
 - *Threat detection*
 - *Battle damage assessment*
- Affordable, organic sensing at the small unit & soldier level
- Multi-mission target & threat information for a wide range of needs
- Integrated with other sensors to provide a more complete picture of the environment

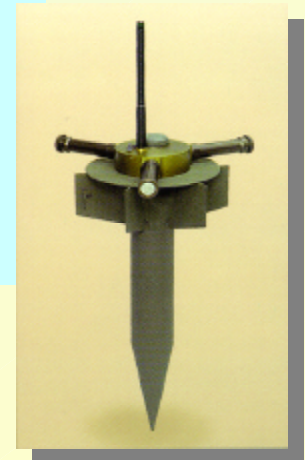
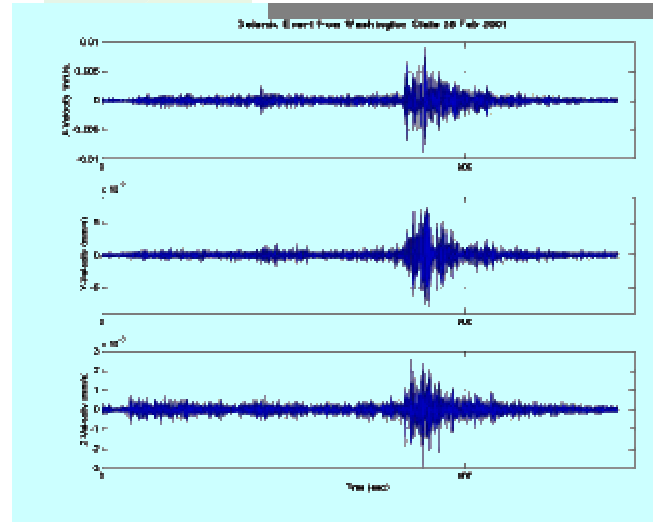


Name that tune!



Acoustic / Seismic Sensors

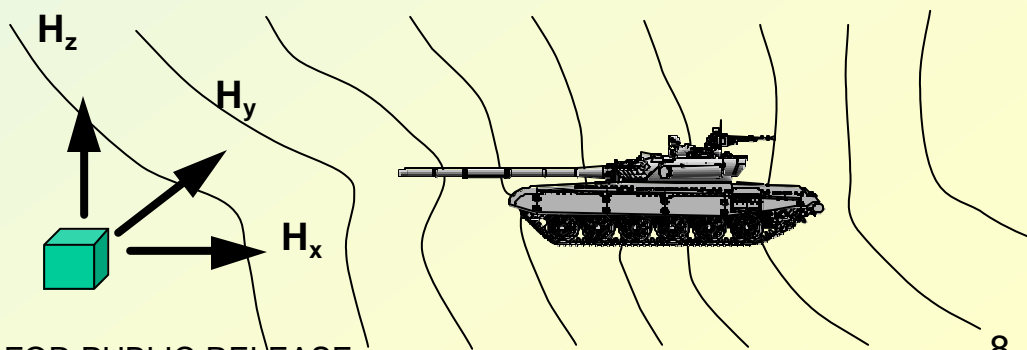
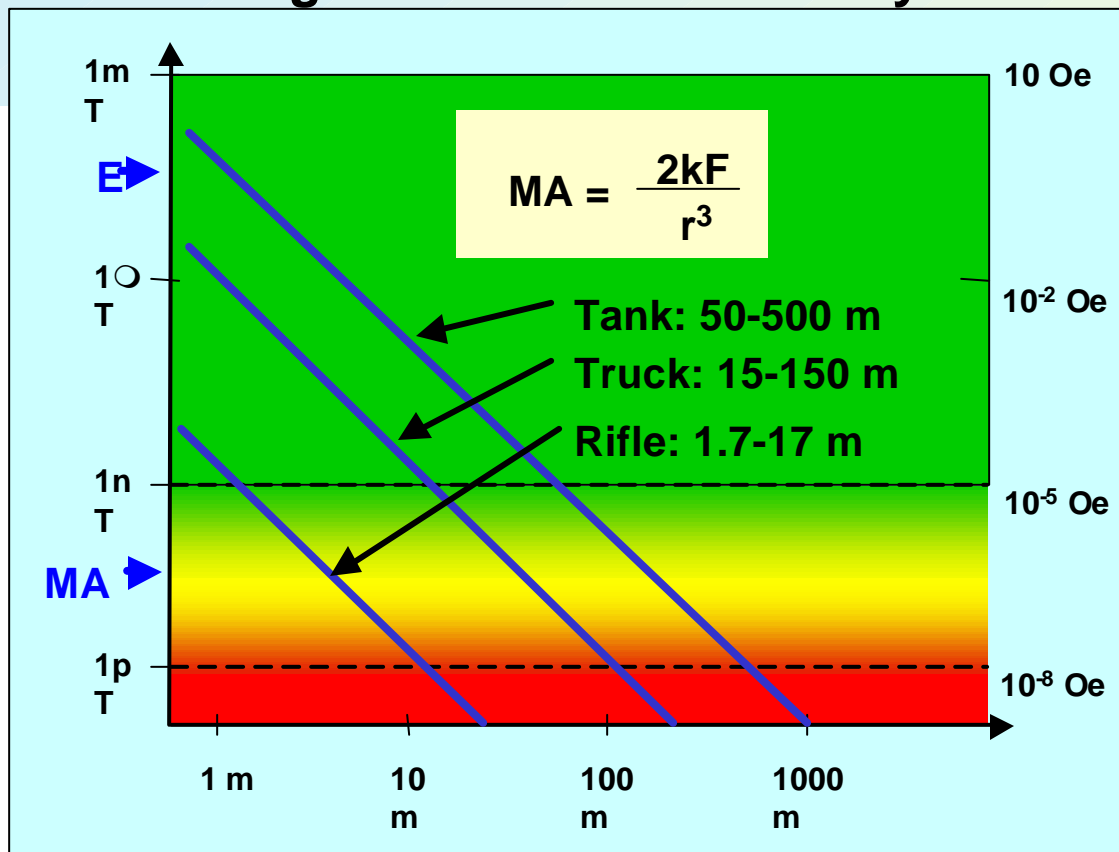
- 360°, NLOS monitoring
- Classifies target
- May ID target
- Provides LOB to targets
- Multiple nodes locate targets
- Detect & ID
 - *Vehicles*
 - *Helicopters*
 - *Artillery, mortar, gunfire*
- Excellent cueing for imagers



Magnetic Sensors

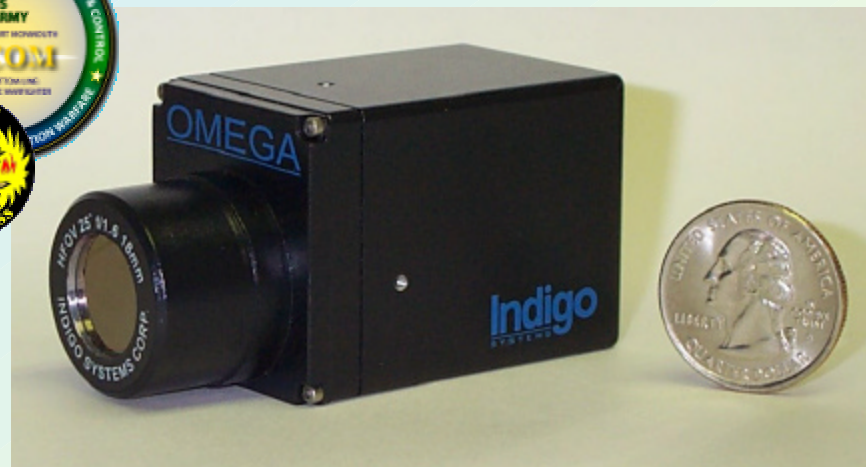
- 360°, NLOS monitoring
- Very low cost
- Very simple
- All weather
- Detect
 - *Vehicles*
 - *Small arms*
- Excellent tripwire sensor to cue other sensors

Magnetic Sensor Sensitivity



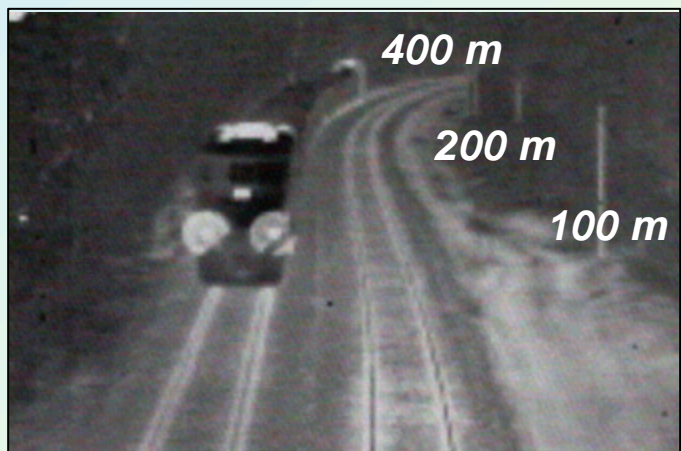
IR Sensor

- Low cost imager
- Low power / size
 - 90 grams
(including optic)
 - 600 mW @ 3.5V
- Excellent target identification



Detection of Walking Man Target

FPA	Sensor Field of Regard/Range	
	40° FOV	15° FOV
160x120	FOR = 164m/ Range= 240m	167m/ 640m
320x240	328m/ 480m	334m/ 1280m

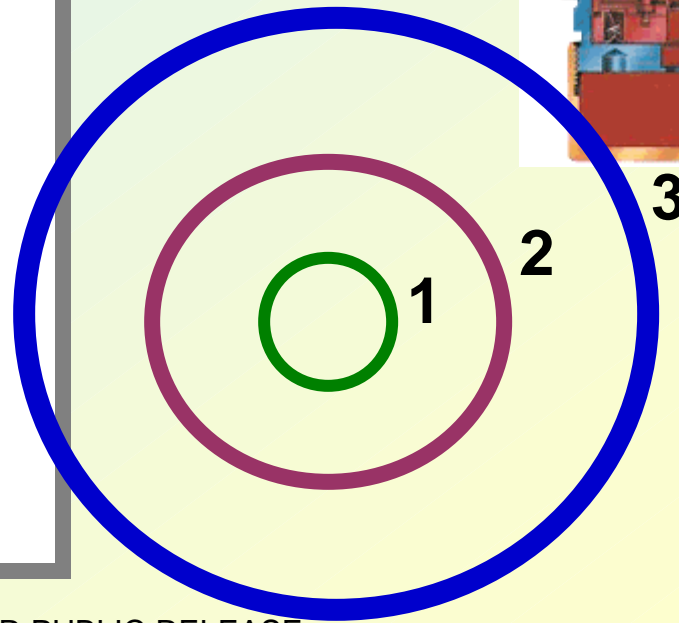
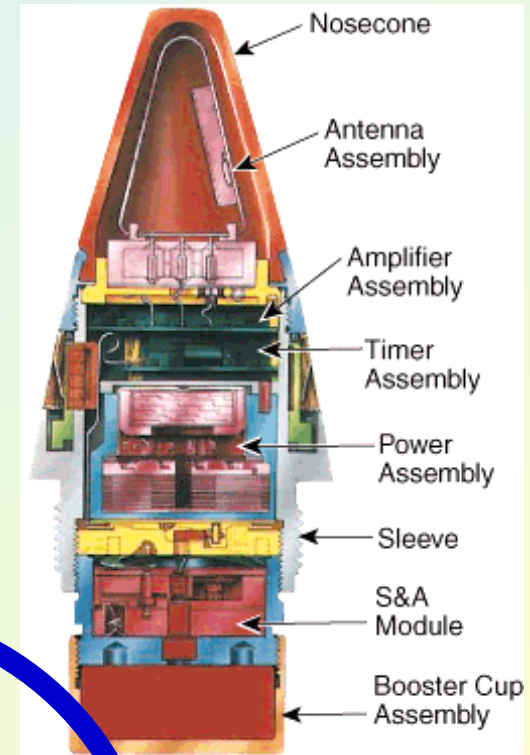


Target: Walking Man (0.75m/2.0° C)
50% Detection/0.75 cycles on target
Atmosphere: 80%/km

Moving Target Indicator (MTI) Radar Sensor

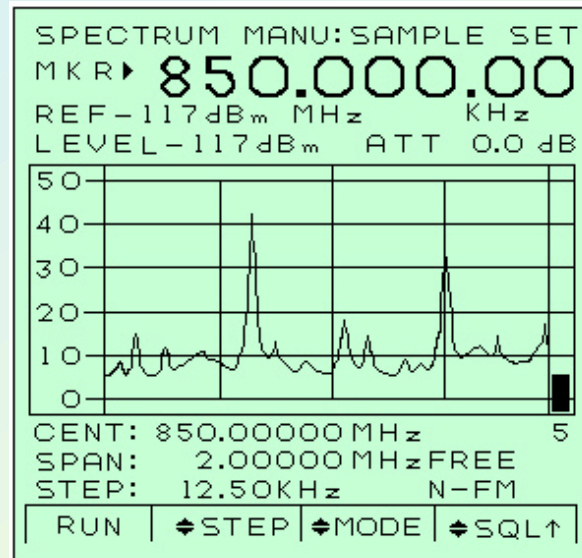
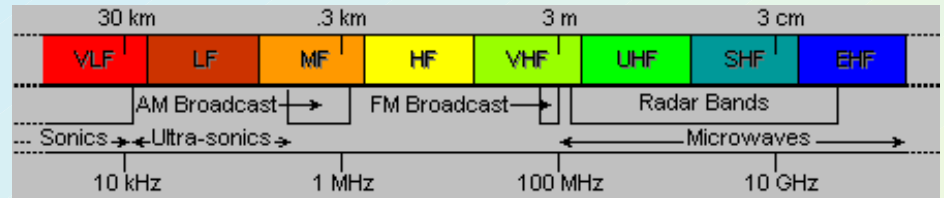
- 360°, NLOS monitoring
- Low cost
- Small, low power
- Detection of moving targets based on Doppler
- Excellent target range information out to > 500m
- Concepts based on Army proximity fuzes
- Simple- multi range cell design

$$P_r = \frac{P_t G_t G_r \lambda^2 \sigma}{(4\pi)^3 R^4}$$

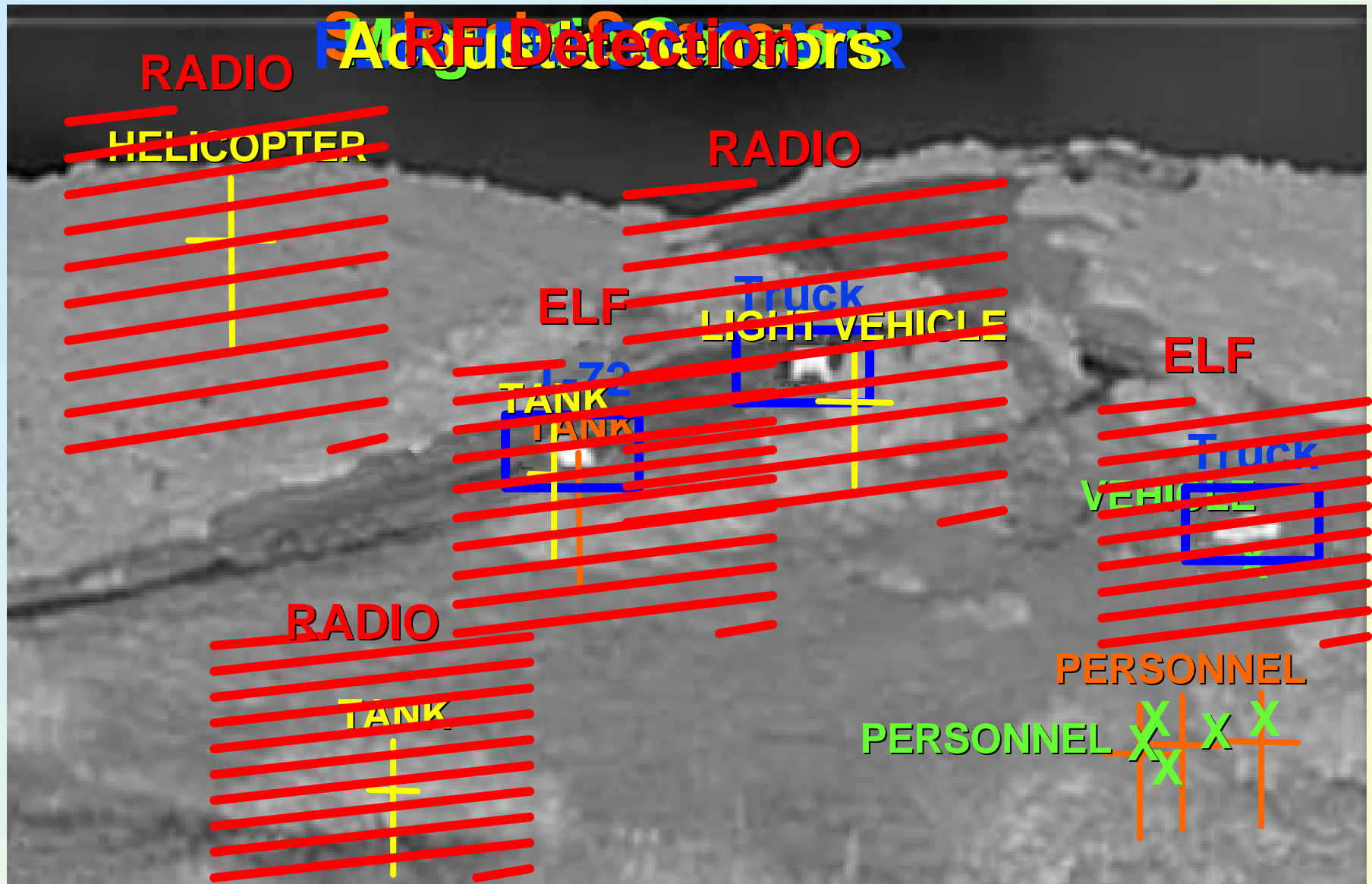


RF Energy Sensor

- Low cost
- Non-line of sight
- Small, low power
- Detection of unintentional RF emissions such as engine noise
- Detection & classification of intentional radio signals

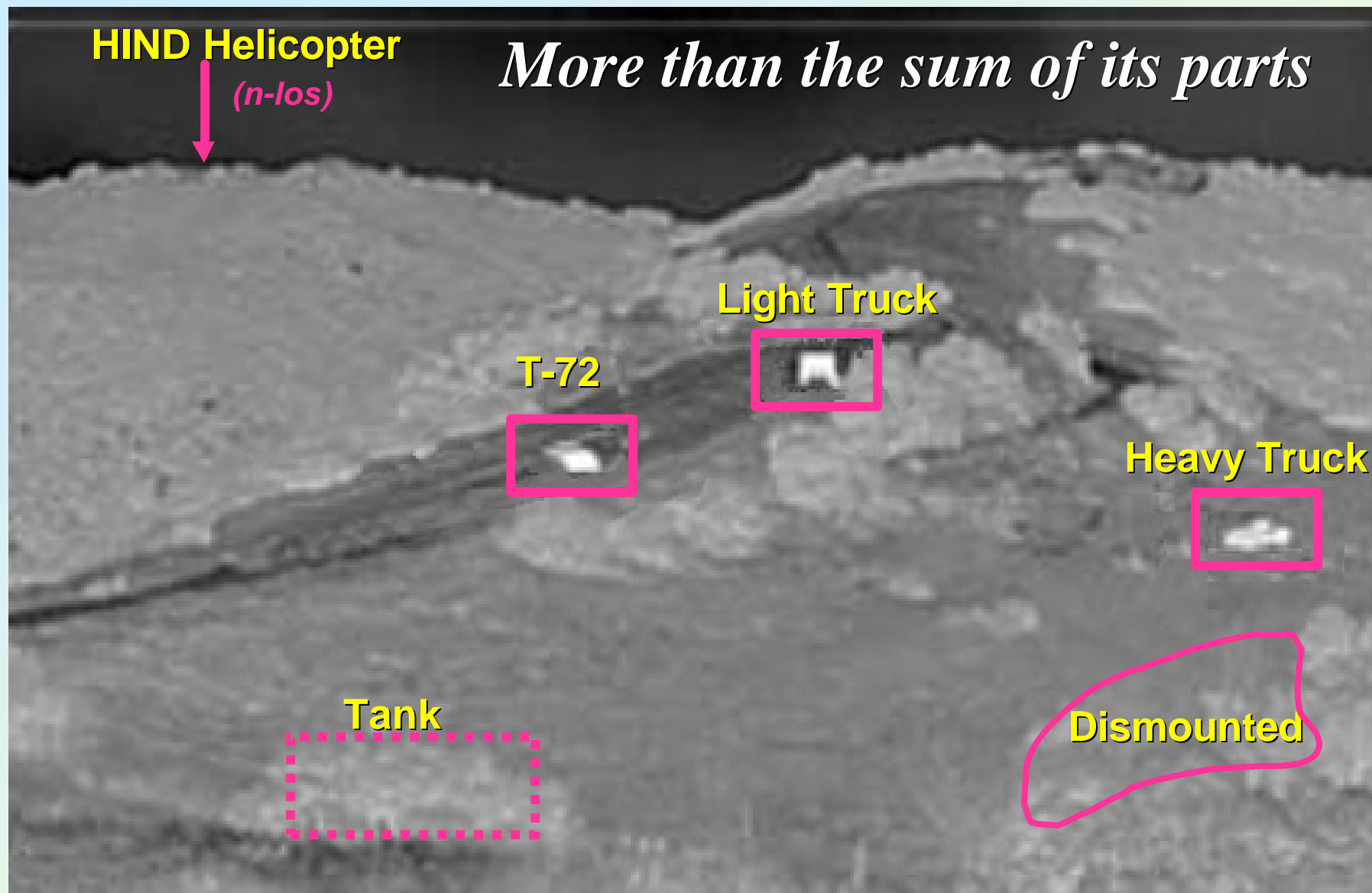


Sensor Fusion



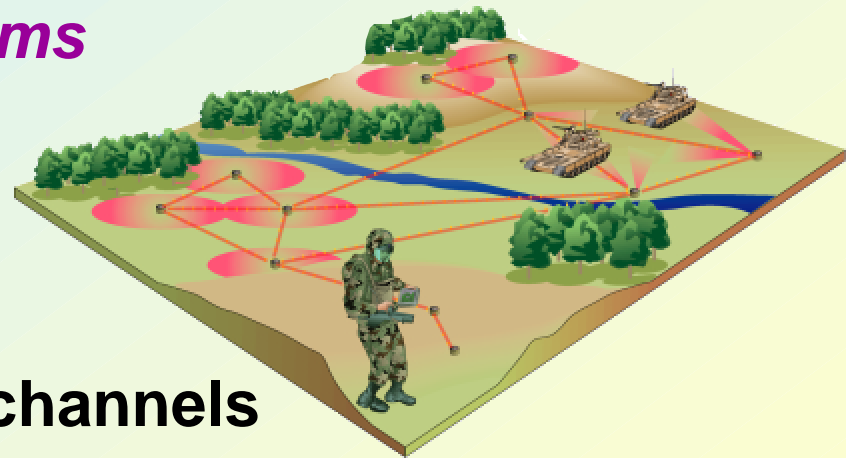
RF Detection

Sensor Fusion Results



Communications

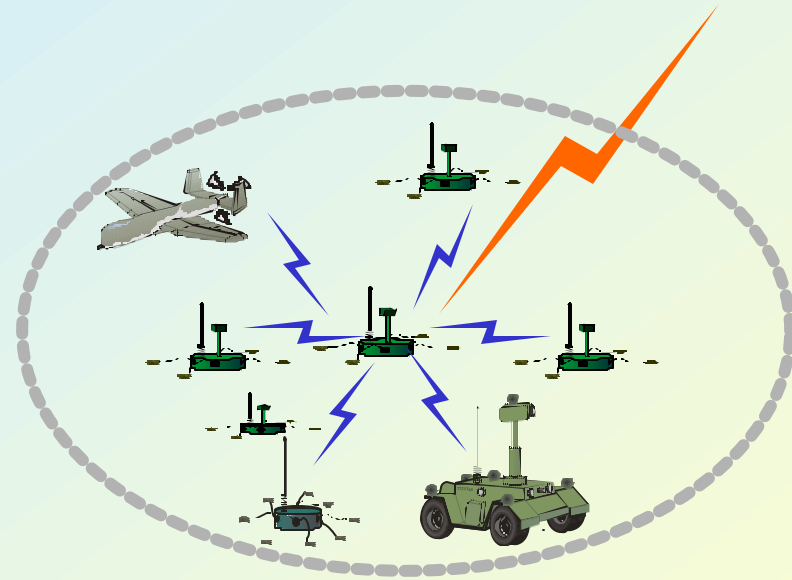
- Provide robust communications in highly energy & bandwidth-constrained environment
- Self-organizing *ad hoc* networks adapting to:
 - *Various delivery mechanisms*
 - *Node failures*
 - *Intermittent connectivity*
 - *Mobility*
- Operate over noisy wireless channels
 - *Local short haul radios*
 - *Long haul radios*
- Protection of the sensor information while forward-deployed & under energy/bandwidth constraints



Radios

■ Short Haul – inter-cluster “Blue”

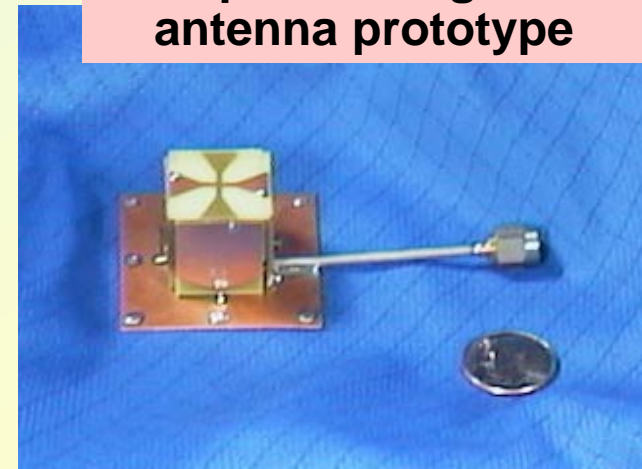
- *Short range – 400 meters*
- *Low bandwidth - <10Khz*
- *Self-configuring, energy-aware*
- *ComSec, LPI/LPD, anti-jam*
- *Receiver energy can dominate power budget!*



■ Long Haul – cluster to C2 network “Orange”

- *Selectable bandwidth – 1 khz data to video*
- *Long range – 10 km or more*
- *ComSec, LPI/LPD, anti-jam*

Compact near-ground antenna prototype



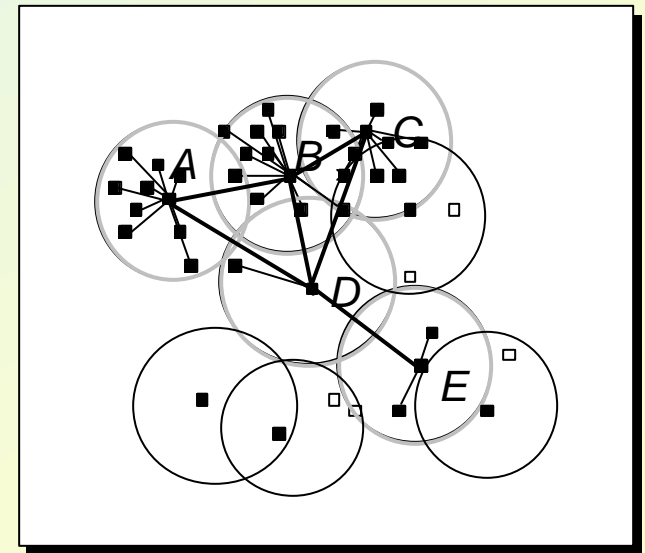
Self-Configuring Routing & Control

■ Linked Cluster *Ad Hoc* Routing Algorithm

- *Network self-organizes under a variety of delivery mechanisms & without prior knowledge of network*
- *Adapts to mobility, channel effects, node destruction or failure*
- *Energy-aware routing & reconfiguration*

■ Control Architecture

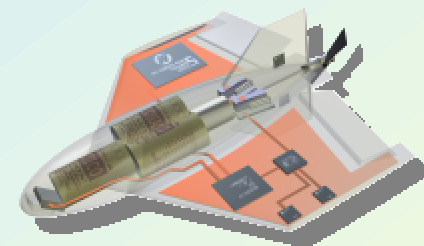
- *Autonomously establishes & maintains the sensor network*
- *Supports range of operational scenarios*
- *Enables low-overhead security*



Modified Ephremides Linked Cluster Routing Algorithm

Node Employment

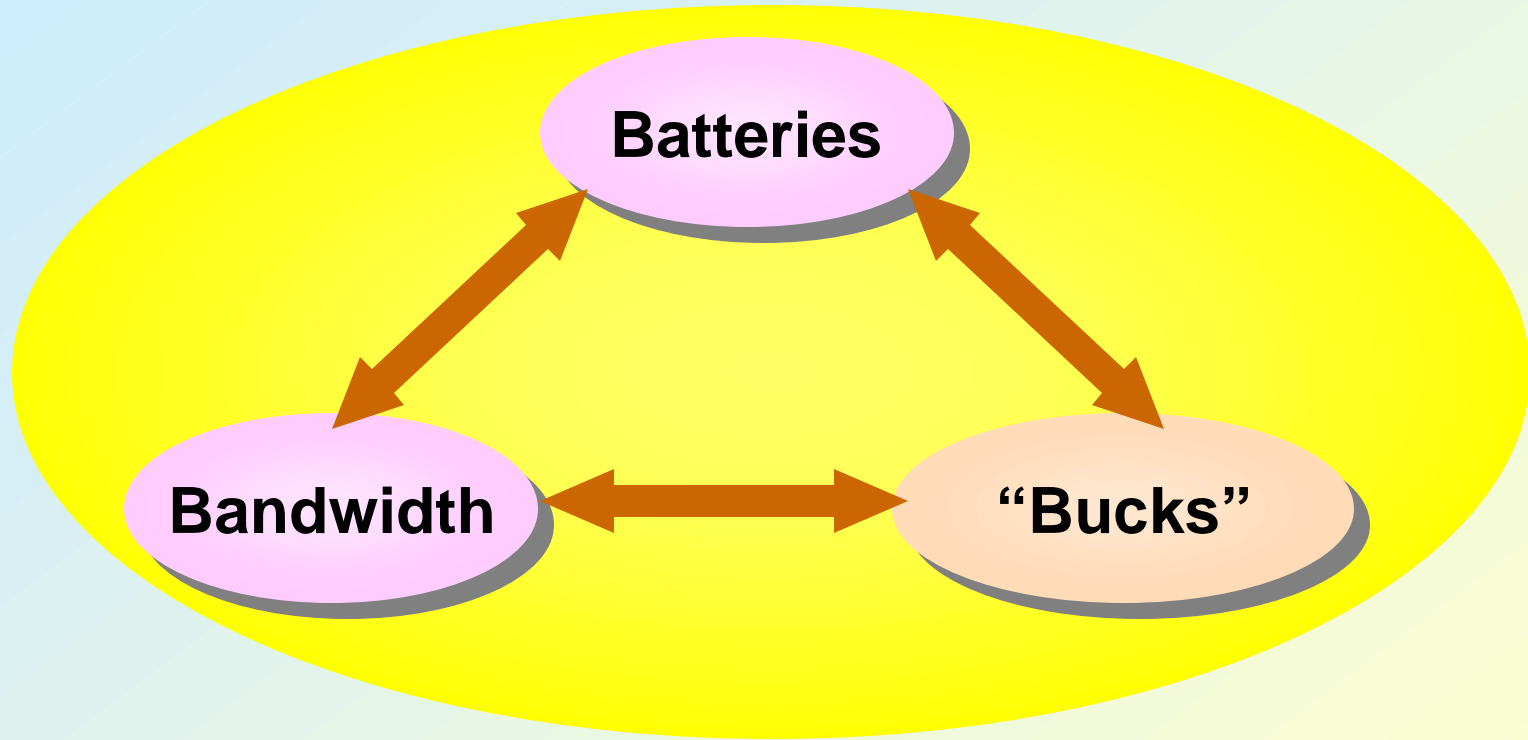
- Hand emplaced
- Artillery / mortar
- Aircraft / helicopters
- Mine dispensers
- Autonomous platforms
 - *Small robots*
 - *Small UAVs*



Small, autonomous platforms will allow sensors to position themselves to optimize sensing and/or communications



Tradeoffs: “The 3 B’s”

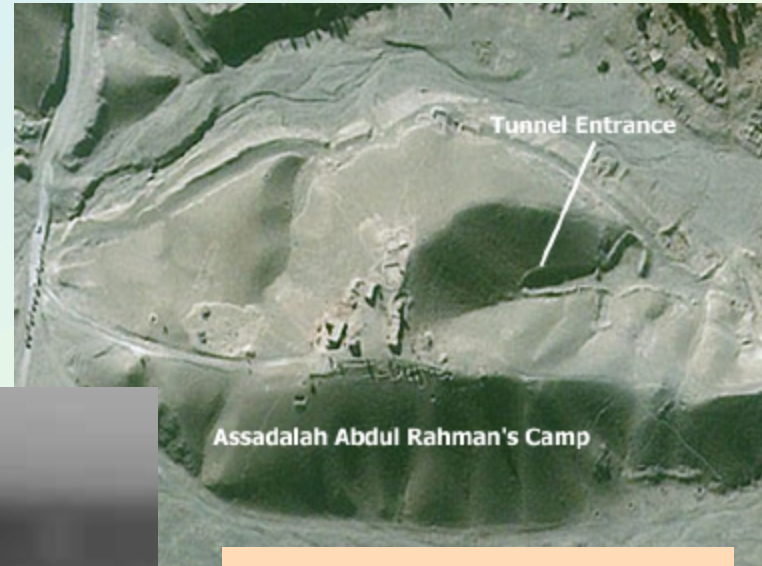


Performance tradeoffs within nodes are complex & require a careful consideration based on the application

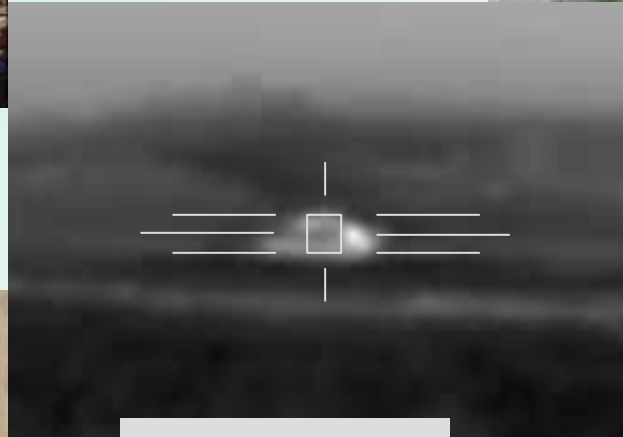
Networked Sensor Applications



Perimeter Defense



Difficult Terrain



Targeting



MOUT Operations



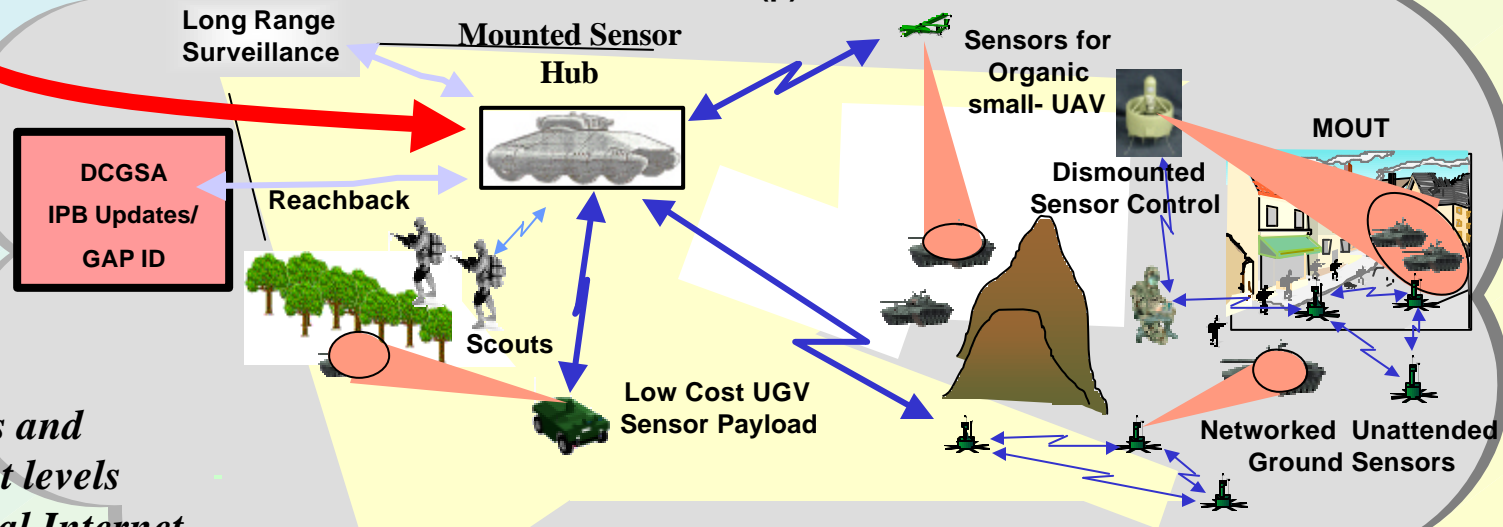
Personnel Detection

Networked Sensors for the Objective Force ATD

Sensors for the Close Fight – BSA+T
... Inside the extended Red Zone

*Organic Low Cost Unmanned Sensors
for the Battlefield Commander*

Networked Sensors for the Objective Force ATD(p)



*Networked Sensors and
Communications at levels
“below” the Tactical Internet*

**Distributed Sensors Fill the Battlefield Situational Awareness Gap and Provide BLOS Targeting
– Complement Global Surveillance –**

Benefits of the Approach

- Provide warfighter with organic capabilities down to individual level
- Internettted, multi-sensor approach insures robust, reliable target information
- Range of employment mechanisms (*hand, air, munitions, robots*) enables diverse uses
- Range of low cost technologies will allow their rapid re-use to meet new requirements

Challenges

■ Communications

- *Energy-efficient, miniature radios*
- *Energy-aware, ad hoc networking*

■ Processing

- *Power conservation*
- *Sensor & data fusion*

■ Sensors

- *Acoustic , seismic, magnetic not mature*
- *New sensing modalities ?*

■ Cost reduction

- *Highly integrated electronics*
- *Packaging*

The Bottom Line

- Many of the enabling technologies already exist
- Key challenges remain
- Up front integration of all elements of nodes are needed to be successful
- All services will benefit from fielding networked unattended sensors

***Not an evolution, but . . .
a revolution in battlefield sensing***